Woody plants play an important role in determining the physical structure of many riparian ecosystems (Gurnell, Bertoldi & Corenblit 2012). Understanding the ecology of woody riparian plants is therefore central to river rehabilitation and riparian conservation efforts.

To thrive near stream channels, plants must navigate a trade-off between ease of access to water and stresses associated with waterlogging or inundation (Naiman, Decamps & Pollock 1993; Colmer & Voesenek 2009). Woody colonists of inset channel features such as bars and benches may experience repeated cycles of soil waterlogging (Corenblit *et al.* 2009), restricting root access to oxygen (Voesenek & Bailey-Serres 2015). Maintaining root respiration in low O2 conditions requires switching to costly anaerobic metabolic pathways (Drew 1997). Reduced respiration weakens root function, impairing uptake of water and nutrients (Piedade *et al.* 2010; Voesenek & Bailey-Serres 2015). Stomatal closure may also take place following waterlogging, reducing available CO2

for photosynthesis (Kozlowski 1984; Else *et al.* 2009). Root-zone hypoxia damages roots by inducing production of toxic ions by microbes (Bailey-Serres & Voesenek 2008), and reactive oxygen species (ROS) within roots as a result of anaerobic metabolic processes (Santosa *et al.* 2007). Subsequent reaeration further increases ROS production (Steffens, Steffen-Heins & Sauter 2013). Waterlogging may impair rhizomicrobial nodule formation and activity (Dawson, Kowalski & Dart 1989; Shimono *et al.* 2012), resulting in reduced nutrient uptake. Anoxia can also cause suberisation of roots (Steudle 2000).

Atmospheric CO2 has risen substantially over the past century, and a doubling of pre-industrial levels by 2100 is projected (IPCC, 2013). As with waterlogging, atmospheric CO2 concentration is known to have profound effects on plant physiology and growth by altering the fundamental economics of carbon, water and macronutrient uptake and use. Individual species responses are variable, but photosynthetic CO2 assimilation in C3 plants (Curtis 1996) tends to increase under eCO2; stomatal conductance is typically reduced (Ainsworth & Rogers 2007), with attendant gains in water use efficiency (Holtum & Winter 2010; Keenan *et al.* 2013; van der Sleen *et al.* 2014). Biomass accumulation in response to eCO2 is typically enhanced (Wang *et al.* 2012), but depends on the availability of water and macronutrients (Körner 2006; Manea & Leishman 2014; Reich, Hobbie & Lee 2014). Increased allocation of biomass to roots occurs under eCO2 (Nie *et al.* 2013), although this effect is interactive with environmental stresses such as drought or low soil fertility (Wang & Taub 2010). Increased rates of production and turnover of fine roots under eCO2 have been shown in the field, with important implications for nutrient cycling and ecosystem functioning (Pregitzer *et al.* 1995, 2000; Matamala & Schlesinger 2000; Lipson *et al.* 2014). eCO2 is also known to affect functional traits indicative of positions along economic spectra (*sensu* Reich 2014). Reduction in specific leaf area (SLA) under eCO2 has been linked to accumulation of non-structural carbohydrates in leaves (Poorter & Navas 2003; Bader, Siegwolf & Körner 2010). Alteration of traits reflecting economic trade-offs is of particular significance at the seedling stage, as functional traits of trees are most strongly adapted to the regeneration niche (Poorter 2007).

Literature describing interactive effects of atmospheric CO2 concentration and waterlogging or flooding on plant growth is sparse, and findings variable. Megonigal et al. (2005) showed that eCO2 stimulated biomass production in waterlogged (water table at -10 cm) but not inundated (water table at +5 cm) juveniles of *Taxodium distichum*. Increased photosynthesis under eCO2 was not reduced by inundation. This effect was attributed to the increased metabolic cost of maintaining roots under low O2 conditions. In the same study, inundation had no effect on eCO2 stimulation of photosynthesis or biomass production of the aquatic herbaceous species *Orontium aquaticum*. The opposite response was found for a highly flooding tolerant Amazonian tree: waterlogged *Senna reticulata* grown in open top chambers showed greater increment in biomass under elevated CO2 (Arenque *et al.* 2014). It is possible that higher water use efficiency under eCO2 (Holtum & Winter 2010) facilitates photosynthesis in plants with anoxia-impaired root functionality by lowering the water cost of carbon assimilation. Finally, no evidence for an interaction between CO2 concentration and waterlogging status was found on growth or stomatal conductance in soybean (Shimono *et al.* 2012). To our knowledge, no studies have investigated the effects of eCO2 on recovery from waterlogging. Recovery following stress events may be more important to fitness than tolerance of the stress (Gutschick & BassiriRad 2003). For waterlogged plants, generation of reactive oxygen species following reaeration is likely to be a significant additional stress (Drew 1997).

The objective of this study was to investigate interactive effects between eCO2 and waterlogging on gas exchange, biomass accumulation and allocation, and functional traits for three riparian tree species. We asked: 1.) are eCO2 effects on gas exchange altered by waterlogging, and is this response maintained following a refractory period? 2.) Is stimulation of biomass production by eCO2 diminished after a refractory period post-waterlogging? 3.) Does CO2 mediate biomass allocation or functional traits in response to waterlogging, or following a refractory period?